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Pacific Rim Resort

WIND MONITORING STUDY

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SUMMARY

The Pacific Rim Resort, on the west coast of Vancouver Island, wished to develop its wind resource for electrical generation. Initial calculations of the wind energy potential of Lennard Island, 3.5 km offshore, indicated that it was marginally acceptable as a wind energy site. There was some wind shielding at the Lennard Island AES site, however, so monitoring at the Pacific Rim site was carried out to determine if it was a more viable location.

SAR Engineering carried out wind monitoring at the Pacific Rim Resort for a period of six weeks. An SAR data logger was used in conjunction with an EMR installed anemometer and tower. Comparison with the hourly measurements from the nearby Lennard Island AES site were made in order to determine the relative wind strength at the measurement site. The long term Lennard Island average wind speed of 4.4 m/s was adjusted to 4.6 m/s to account for some shielding at its site. It was then further modified to reflect the relative strength at the Pacific Rim measurement site. This value was then used in wind energy calculations.

Severe wind shading was found at the measurement site - winds from the East through Southeast were only about 20% to 30% of those for Lennard Island. The anemometer was shielded by trees to the East and therefore the entire set of monitored data could not be used for comparison with Lennard Island. Wind speeds from the unshielded West to Southwest were about 82% of those at Lennard Island. This value was used to adjust the Lennard Island long term wind speed - giving a value of 3.8 m/s.

An Adecon 150 kW VAWT would produce about 65,000 kWh per year with an average wind speed of 3.8 m/s. This value was about a quarter of that originally estimated. The turbine was costed at $210,000 installed, with some free labor provided by the owners. This figure, and an estimated $5,000 per year operating cost would result in a cost of energy of 40¢ per kWh, based on a 10 year simple payback. Since electricity is presently available at the site from B.C. Hydro at a cost of 5¢ per kWh, wind generated electricity is clearly not viable at the Pacific Rim Resort.

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1 INTRODUCTION

The operators of the Pacific Rim Resort advised EMR that they wanted to investigate the possibility of exploiting the wind resource at their site on the west coast of Vancouver Island. The Resort is connected to B.C. Hydro power lines so relatively inexpensive electrical power is available. An initial analysis by Mr. Roger Bryenton of EMR, using modified Lennard Island AES data (about 3.5 km offshore from the Resort), showed the site to be marginally acceptable[1] from a cost point of view. The Lennard Island site is partially wind-shaded from the North through East by conniferous trees at about the same elevation as the anemometer sensor. It was therefore decided to monitor winds for a short period of time and compare them with Lennard Island for the same period to see if winds from the North through East would be strong enough to improve the viability of the project.

SAR Engineering contracted with the B.C. CREO of EMR to carry out wind monitoring and data analysis at the Pacific Rim Resort on the west coast of Vancouver Island.

1 The analysis for a VAWT (Vertical Axis Wind Turbine) in the 50 kW to 150 kW range indicated that cost of power production would be about $0.07 per kWh, based primarily on capital cost (the owners would supply most of the labor for installation) and an adjusted average wind speed to account for wind shielding. This is cost-competitive with B.C. Hydro rates of about $0.05 per kWh.

2 SITE DESCRIPTION

The wind measuring site was located at the Pacific Rim Resort, on the west coast of Vancouver Island (Figure 2.1), 10 km south of Tofino and adjacent to the Pacific Rim National Park north boundary. The Atmospheric Environment Service wind measuring station of Lennard Island is located 3.5 km offshore (Figure 2.2).

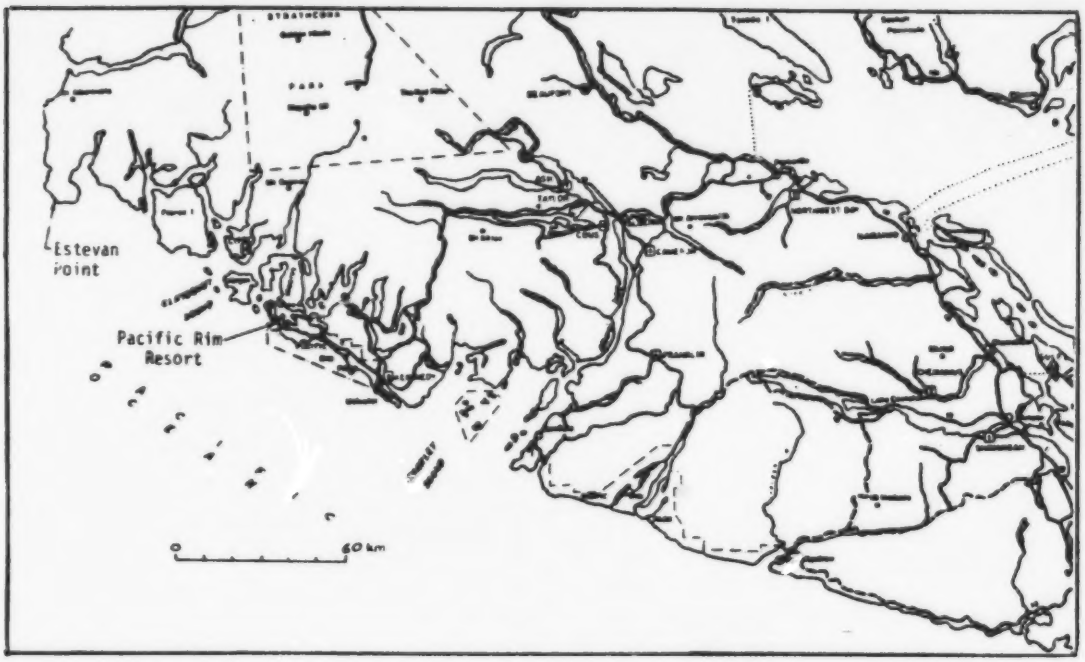


Figure 2.1 Lower Vancouver Island

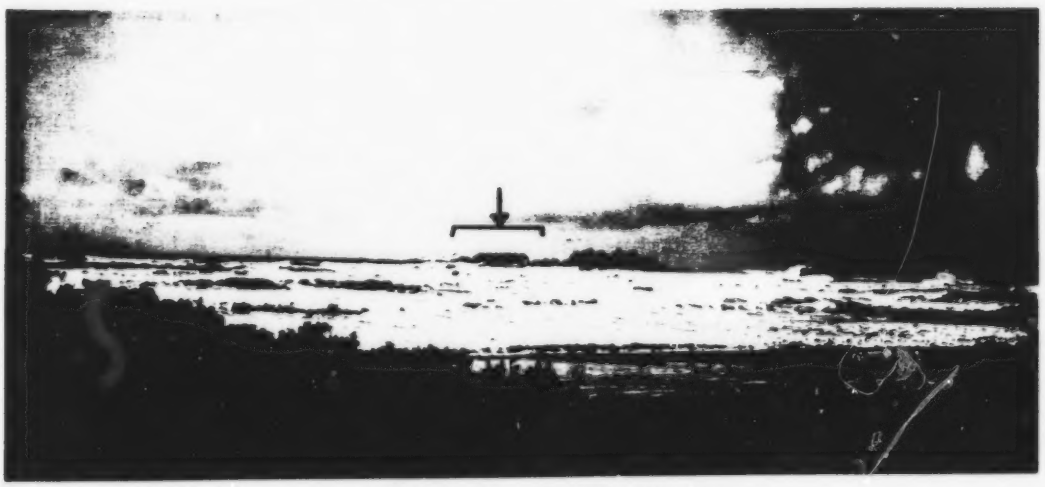


Figure 2.2 Lennard Island from Pacific Rim Resort

The wind monitoring equipment and 15 metre tower were set up immediately behind the beach amongst trees that were approximately 8 to 10 meters high (Figure 2.3).

Figure 2.3 Anemometer and Tower installation

Trees inland of the tower were taller, however - probably at least as tall as the tower (Figure 2.4).

Figure 2.4 Tree profile near Anemometer

3 METHODOLOGY

EMR supplied and installed a 50 foot (15.3 m) tower with anemometer and histogram recorder. Data from the histogram recorder was to be collected at least monthly and sent to TES in Ottawa for processing. This data was to be used for energy analysis purposes and as a backup to the hourly data collected by SAR Engineering.

EMR staff also installed SAR Engineering's Campbell Scientific CR21 data logger and connected it to the histogram recorder's anemometer. The data logger was programmed to record hourly average wind speed for comparison with Lennard Island data. The initial intent was to record and compare about four months of data for the two sites over the period from February through May, 1987.

After performing a statistical comparison of data for the two sites, the long term Lennard Island data was to be adjusted to account for the differences found in the monitoring, and the approximate long term energy available determined, using mean wind speeds. The reason for using this method was that the monitoring period was to be too short to enable reliable energy values to be determined from the site measured data.

4 RESULTS & ANALYSIS

4.1 Installation

Prior to installation, all the equipment was tested and adjustments made to ensure that all the components were compatible. This process and the late arrival of the equipment meant that installation took place in early March - about one month behind schedule. While the battery-powered data logger was programmed prior to leaving the EMR office, during the installation the program was erased without the on-site personnel realizing it. As a result, EMR and SAR personnel had to make another trip to the site. The system became fully operational on March 25th.

4.2 Data

Data was collected from March 25th to May 6th, 1987. Data for Lennard Island, for the same period, was obtained from AES and entered by hand. Measured wind speeds were found to be significantly less than those for Lennard Island (Figure 4.1 is an example for the first week of April; See the Appendix, Section 7.1 for the rest of the data).

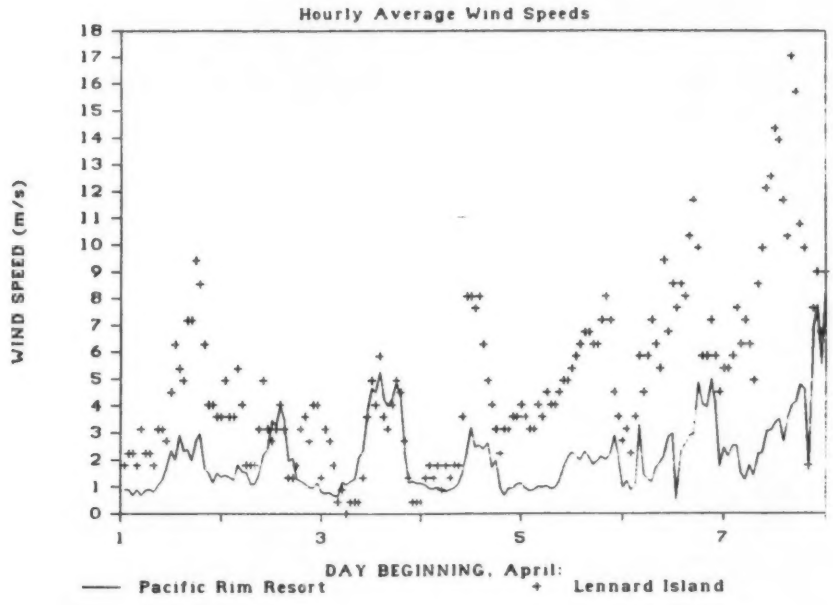


Figure 4.1 Hourly Average Wind Speeds
(April 1 to 7, 1987)

Comparison of the two sites by direction showed that, while the Pacific Rim wind speeds were about 75% to 85% of those for Lennard island for winds from the west and southwest, wind speeds from the east and southeast were only 20% to 30% (Figure 4.2). There was apparently significant shielding of the anemometer by the trees - primarily affecting winds from the east and southeast, but also affecting winds from the south and northwest (parallel to the beach).

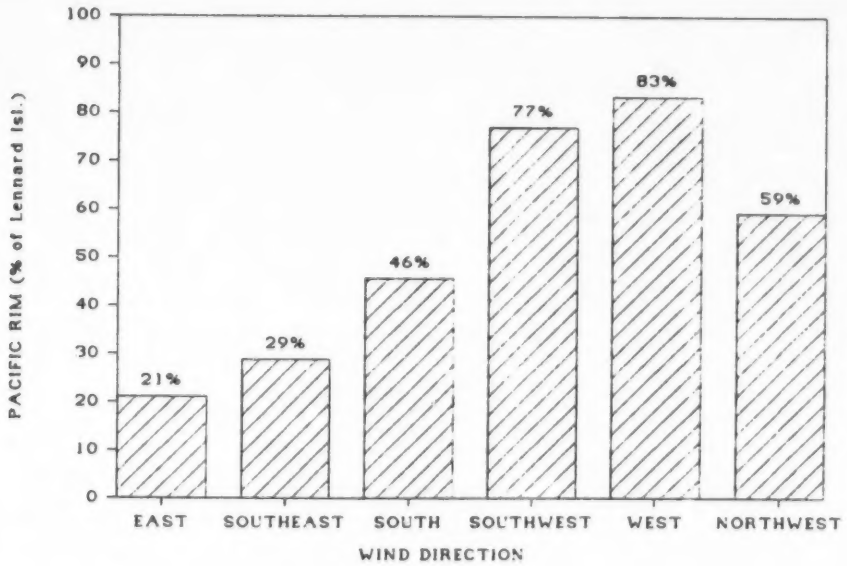


Figure 4.2 Comparative Wind Speeds by Direction

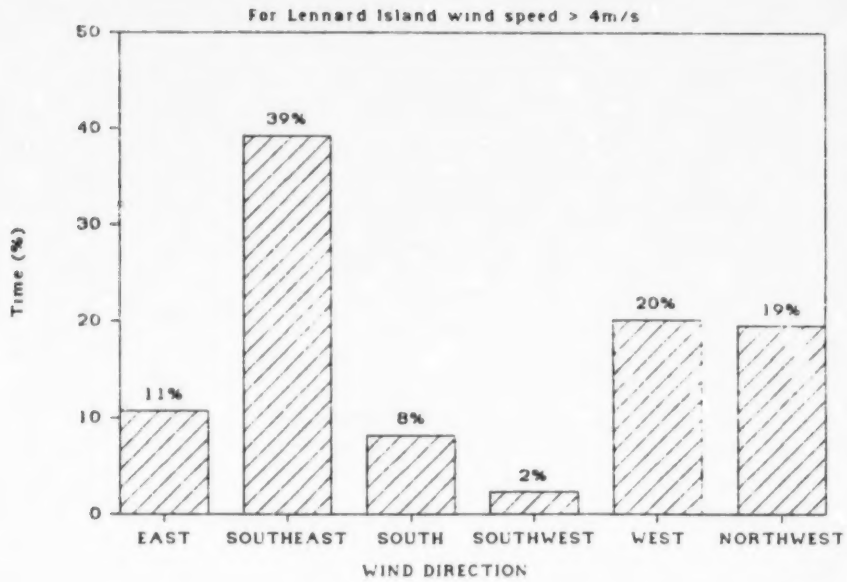


Figure 4.3 Wind Duration by Direction

Additional tower lengths were supplied to the operators of the Resort to raise the anemometer, but since the wind speeds from the unshielded west and southwest averaged less than those for Lennard Island, they felt that it would not be worth the effort to continue measuring. Monitoring was therefore discontinued and analysis was carried out for the limited data available.

4.3 Analysis

Measured wind speeds at Pacific Rim averaged only 48% (Table 4.1) of those for Lennard Island, however significant wind shielding by nearby trees appears to be at least partly to blame for the difference.

Table 4.1 Comparison of Pacific Rim and Lennard Island
(March 25 to April 30, 1987)

Lennard Isl. Wind Speed > 4m/s

DIRECTION	NUMBER OF HOURS	SPEED (m/s) PACIFIC RIM	LENNARD ISLAND	COMPARISON
East	51	1.33	5.99	21%
Southeast	187	1.96	7.14	29%
South	39	2.54	5.85	46%
Southwest	11	5.78	7.42	77%
West	96	6.42	7.71	83%
Northwest	93	5.37	7.74	59%

SUM:	477	hours >4 m/s wind

AVERAGE OF ALL HOURS (25 Mar - 30 Apr):

ALL DIRECTIONS	875	3.24	6.72	48%

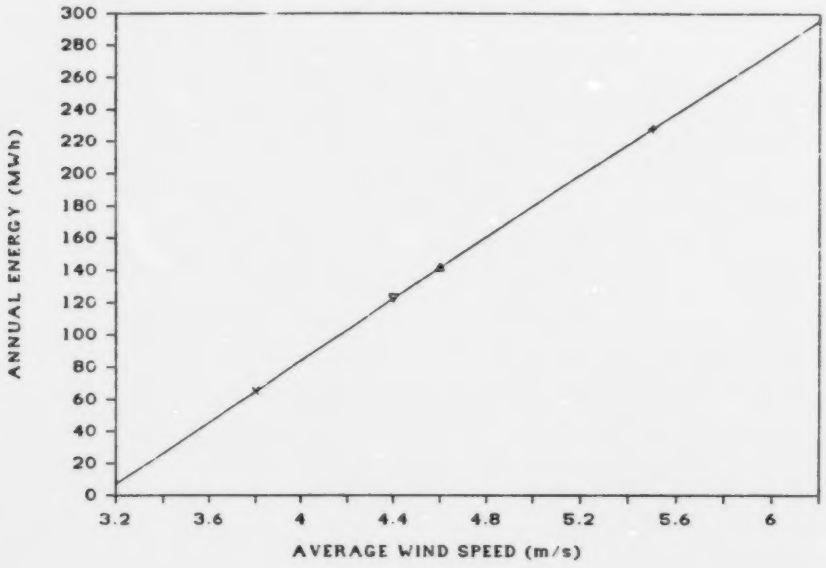
If a frequency-weighted comparison is made for the unshielded west and southwest directions only, then Pacific Rim wind speeds are about 82% of those for Lennard Island for the measured period. This probably represents an upper limit of what can be expected for the Pacific Rim site.

Approximate annual energy output was determined for several sites:

Table 4.2 Sites Investigated for Annual Wind Energy Output

SITES	DESCRIPTION	WIND SPEED (m/s)
Estevan Point	60 km NW of Pacific Rim Resort Anemometer mounted on lighthouse. Located on SW corner of Hesquiot Peninsula. Excellent exposure SE through West to NW Exposure somewhat restricted from NW through East to SE due to trees and 60 m hills of Hesquiot Peninsula.	5.5
Lennard Island	3.5 km West of Pacific Rim Resort On West side of island 1 km in diameter. Good exposure to all directions except North through East where the light tower, dense tall trees and power house affect the readings.	4.4
Lennard Island (adjusted)	North through East wind speeds adjusted to be equal, as a percentage of mean speed, to that for Estevan Point.	4.6
Pacific Rim Resort (adjusted)	Taken as 82% of that of adjusted Lennard Island wind speed.	3.8

The performance curve for an Adecon 150 kW VAWT (Vertical Axis Wind Turbine) was used to determine approximate annual energy output for each of the sites (Figure 4.4).



+ Estevan Pt. ∇ Lennard (Meas.) Δ Lennard (Adjust.) × Pacific Rim (Adjust.)

Figure 4.4 Annual Energy Output (Adecon 150 kW VAWT)
(Rayleigh wind speed distribution)

The normal 'one-off' price for the Adecon 150 kW VAWT is $185,000 however a price quote of $105,000 was received for this application. In consultation with Roger Bryenton, EMR and the Pacific Rim Resort operators, we estimated the cost of installation to be $105,000 assuming that the owners contributed considerable labor. Total installed cost would therefore be $210,000. Annual operating cost was estimated to be about $5,000. With a simple payback of 10 years, the annual operating plus amortization cost would come to $26,000. No allowance was made for interest charges, however comparison was made with the present cost of electricity, with no allowance for inflation.

Table 4.3 Estimated Annual Energy Output and Cost

SITES	WIND SPEED (m/s)	ENERGY OUTPUT (kWh/year)	10 year cost
Estevan Point	5.5	228,000	11 ¢/kWh
Lennard Island	4.4	122,000	21 ¢/kWh
Lennard Island (adjusted)	4.6	142,000	18 ¢/kWh
Pacific Rim Resort (adjusted)	3.8	65,000	40 ¢/kWh

In comparison with the 30¢ to 40¢ per kWh typical of diesel electric plants, these wind electric systems range from very cost effective for the Estevan Point wind regime to cost competitive for the Pacific Rim Resort wind regime. *However*, when compared with the 5¢ per kWh cost of electricity (B.C. Hydro) available at the Pacific Rim Resort, wind generated electricity is 8 times as expensive with the probable wind regime available at the site.

5 CONCLUSIONS

A complete site assessment must be carried out prior to installation of wind monitoring equipment to ensure that wind shielding, excessive turbulence, etc. will not adversely affect the wind monitoring. In this case the 15 metre tower was about 50% taller than trees in the immediate vicinity, but was about equal to the height of trees 20 to 30 metres inland. As a result, significant errors were introduced into the monitored results.

With the provisos that conclusions are based on a short period of only six weeks of monitoring and on results that required modification due to wind shielding, the Pacific Rim Resort is not a viable site for wind generated electricity. Wind speeds are probably less than 82% of those at Lennard Island. The site would probably be marginally acceptable if the alternative were diesel generated electricity, but is not acceptable since relatively inexpensive electricity is available from B.C. Hydro.

6 ACKNOWLEDGEMENTS

SAR Engineering are very grateful for the assistance rendered by Messrs Bryenton and Bowen of the Vancouver CREO, EMR. We would also like to thank the staff at the Pacific Rim Resort for their assistance in changing data tapes.

7 APPENDICES

7.1 Graphs of Hourly measured Data:

- March 25 to 31, 1987
- April 1 to 7, 1987
- April 8 to 14, 1987
- April 15 to 21, 1987
- April 22 to 28, 1987
- April 29 to 30, 1987

7.2 Comparison of Wind Between Sites

7.1 Hourly measured Data

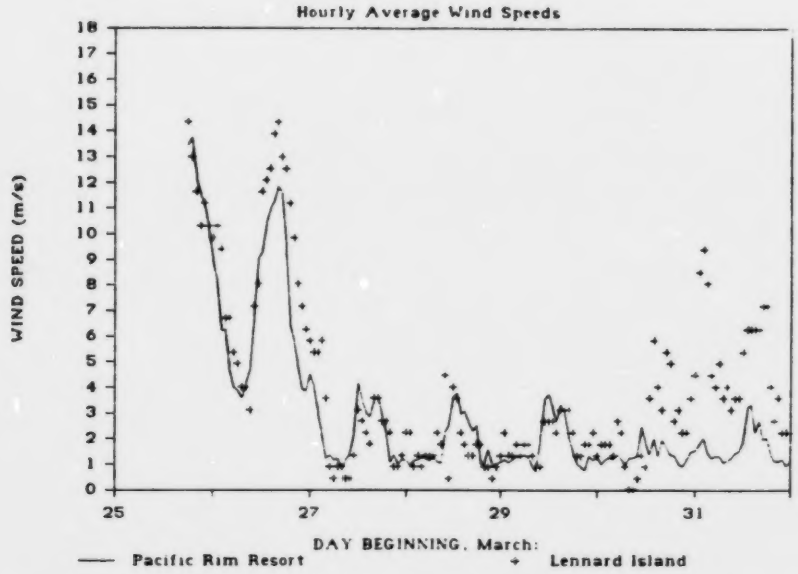


Figure 7.1 Hourly Average Wind Speeds (March 25 to 31, 1987)

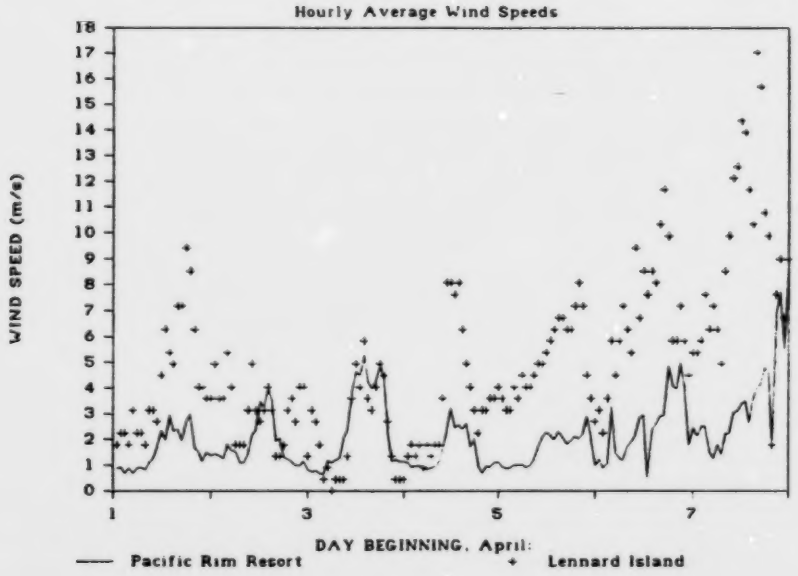


Figure 7.2 Hourly Average Wind Speeds (April 1 to 7, 1987)

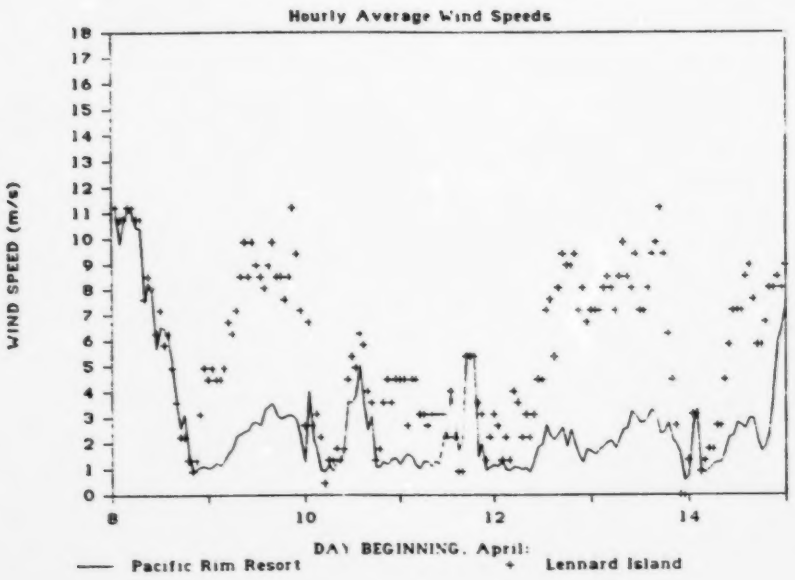


Figure 7.3 Hourly Average Wind Speeds (April 8 to 14, 1987)

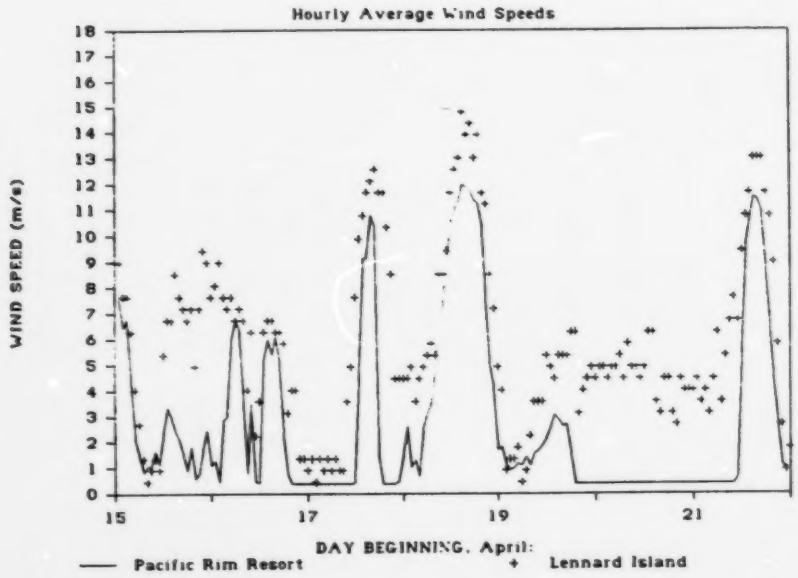


Figure 7.4 Hourly Average Wind Speeds (April 15 to 21, 1987)

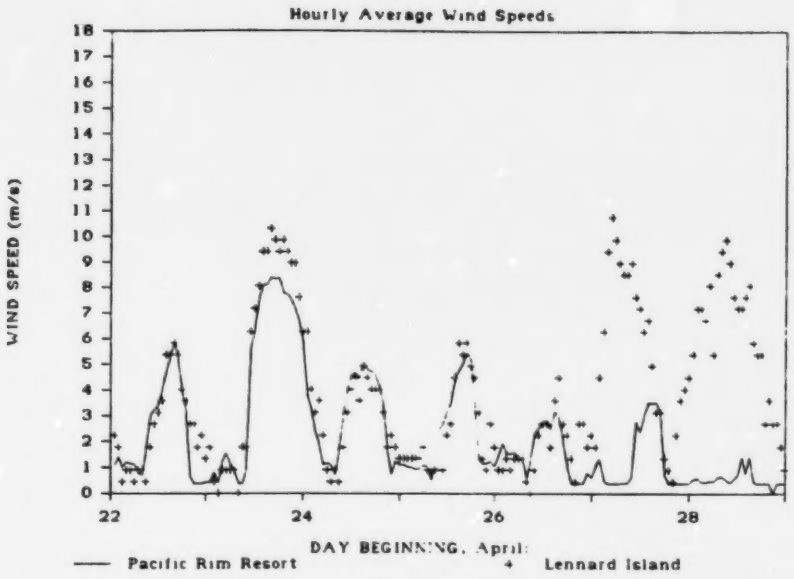


Figure 7.5 Hourly Average Wind Speeds (April 22 to 28, 1987)

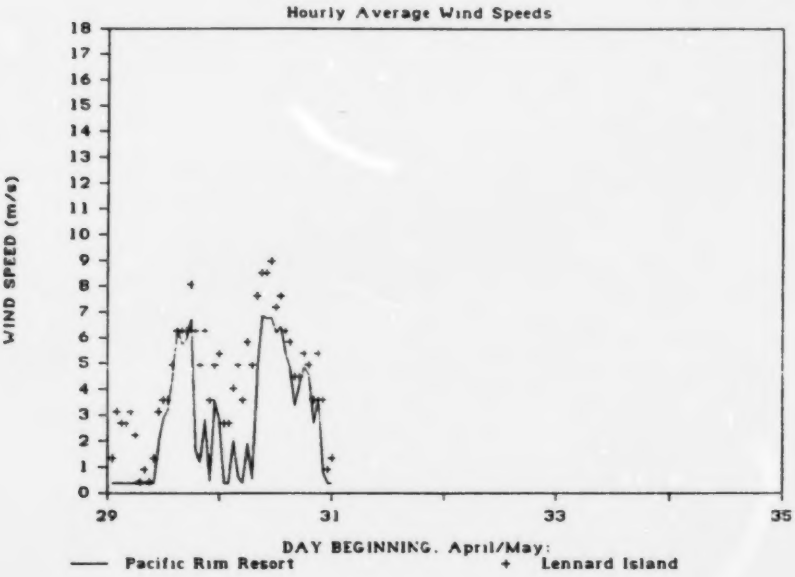


Figure 7.6 Hourly Average Wind Speeds (April 29 to 30, 1987)

7.2 Comparison Between Sites

Table 7.1 Comparison of Winds Between Sites

	ESTEVAN PT. (1963-1980) ANNUAL			LENNARD IS. (1971-1980) ANNUAL			LENNARD vs ESTEVAN PT.		LENNARD
Direction	Speed (m/s)	Freq.	Speed % of Mean	Speed (m/s)	Freq.	Speed % of Mean	% of Mean Speed	Freq.	Adjusted (m/s)
NORTH	4.7	11.7%	86%	2.0	5.4%	46%	54%	46%	3.8
NE	2.0	5.0%	37%	1.5	5.4%	34%	92%	108%	1.6
EAST	3.8	13.5%	70%	2.6	12.7%	59%	84%	94%	3.1
SE	6.1	26.6%	111%	5.2	32.6%	118%	107%	123%	5.2
SOUTH	5.7	9.2%	105%	5.1	7.6%	116%	111%	83%	5.1
SW	4.7	4.1%	85%	4.1	4.0%	92%	108%	98%	4.1
WEST	6.2	7.4%	113%	3.7	6.5%	84%	75%	88%	3.7
NW	7.1	21.4%	130%	5.6	25.2%	126%	97%	118%	5.6
CALM		1.1%			0.6%				
ALL DRCTNS	5.5			4.4					4.6